SEASONAL VARIATIONS IN CERTAIN SPECIES OF MOSQUITOES (DIPTERA, CULICIDÆ)

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It is the purpose of this paper to point out seasonal variations in structure, coloration, and size of adults and larvæ of certain mosquitoes of the genus *Culex*. In some cases such variation may have led to unnecessary multiplication of specific names. It is of importance, also, since the apparently less studied winter forms of some of the species do not run to the correct point in certain keys.

Seasonal variations are well known in many groups of insects. In mosquitoes the winter individuals are often larger than the summer ones and slight color variations have been noted. Thus the overwintering females of *Anopheles maculipennis freeborni* Aitken in California are larger and darker than the summer forms.[1] The same appears to be true of the related *Anopheles quadrimaculatus* Say.

The specimens studied in the preparation of this paper have all come from the southeastern United States. Many of them were collected at Camp Shelby, near Hattiesburg, Mississippi, by Mr. Wm. V. Reed, Capt. Basil G. Markos, the author, and others. For the opportunity to study numerous other specimens from other parts of the southeast, the author is indebted to Major Stanley J. Carpenter, Major W. W. Middlekauff, Lieutenant Louis M. Roth, and other personnel in the entomology department of the Fourth Service Command Laboratory.

CULEX (NEOCULEX) APICALIS ADAMS

Among the species of *Culex* occurring in the southeastern states, the most conspicuous seasonal variation is found in *Culex apicalis*. This holarctic species breeds throughout the year in this area.

[1] Freeborn, S. B. 1932. The seasonal life history of *Anopheles maculipennis* with reference to humidity requirements and "hibernation." Amer. Jour. Hyg., 16: 215.

Larvæ, as well as adults, collected in the cooler months of the year differ markedly from those found during the summer.

The differences which have been noted in adults between a midwinter series and midsummer series are indicated in the following tabulation:

Summer form	*Winter form*
Smaller, wing scarcely over 4 mm. in length.	Usually larger, wing 4 to 5 mm. in length.
Abdominal bands sometimes represented only by lateral spots, more often complete but only one or two rows of scales in width.	Abdominal bands normally broad, three or sometimes four scales in width, rarely with a partial fifth row.
Integument of mesoscutum light brown, rarely infuscated.	Integument of mesoscutum usually infuscated or blackish.
Under surfaces of tibiæ with scales mostly pale.	Under surfaces of tibiæ with scales usually almost all black.
Upper surfaces of femora with dark scales often not reaching bases.	Upper surfaces of femora with dark scaled area frequently reaching bases.

All the characters listed in the above tabulation vary between the extremes, and occur in different combinations with one another. It is therefore believed that only one species is involved, although a large, broad-banded, dark-legged winter specimen with dark mesoscutal integument looks like a different species from a summer specimen. No genitalic differences between such individuals could be found.

Small specimens almost invariably lack or have only narrow abdominal bands, although they may have an infuscated mesoscutum. Many large specimens, particularly during spring and fall, also have narrow bands, and a few large ones have brown mesoscuta. The percentage of large individuals and also of those having infuscated mesoscuta decreases more slowly in spring and increases more rapidly in fall than does the percentage of individuals with broad bands. Apparently these characteristics and band width are affected by different environmental factors or by the same factor or combination of factors acting at different thresholds.

Because, as already stated, there are all intergrades between the extremes for each character, an arbitrary line had to be selected

in gathering data for the following table, between, for example, "infuscated" and "not infuscated." The mesoscutal integument of the midsummer individuals recorded as infuscated is, as a rule, paler than that of winter individuals. Table 1, based on 206 specimens collected at localities more than thirty miles from the Gulf coast in Mississippi, Alabama, and Georgia, shows the seasonal distribution of certain of the characters discussed above. The localities from which these specimens were obtained are Atlanta, Augusta, Hinesville, Macon, Savannah, and Valdosta, Georgia; Anniston and Ozark, Alabama; and Centerville, Grenada, and Hattiesburg, Mississippi.

TABLE 1

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Per cent with bands three or more scales wide	88	100	67	33	20	0	0	0	0	0	50	91
Per cent with infuscated mesoscutum	100	100	67	88	80	43	0	17	10	0	83	100
No. of specimens studied	18	23	30	18	20	7	11	12	10	10	36	11

Similar results were obtained from a study of about 30 additional specimens from North Carolina (Durham, Fayetteville, Hoffman, Laurinburg), South Carolina (Greenwood, Spartanburg), and Tennessee (Smyrna), except that one specimen from near Fayetteville, North Carolina, collected in January and one from Greenwood, South Carolina, collected in November, are small with narrow bands and not or scarcely infuscated mesoscuta.

The seasonal variation here described does not occur throughout the range of *C. apicalis*. In the northern states, and in the west as far south as Arizona (the type locality of *apicalis*), specimens are of the broad-banded type even in summer (according to a letter from Dr. Alan Stone dated January 28, 1944). In the southeastern region such broad-banded specimens disappear during the summer, being replaced by a narrow-banded form. The narrow-banded type occurs, as shown by specimens in the United States National Museum, at least as far north as Maryland. There is evidence that in Florida, and possibly in a narrow zone along the Gulf coast, the broad-banded form does not occur even in

winter. Eighteen specimens collected at Panama City and Marianna, Florida, in November, December, and February are small with narrow bands as in summer individuals farther north. Approximately 40 other specimens from these same localities and from Jacksonville, Florida, collected from April to June are indistinguishable from the winter specimens collected in the same area. This Floridian population which appears to be narrow-banded throughout the year does not represent the extreme in band reduction in this group, however, for in Mexico *C. derivator* Dyar and Knab, which is apparently only a subspecies of *apicalis*, lacks pale scaling on the abdominal terga altogether or, at most, has small white areas latero-apically.

Unfortunately, the species appears to be scarce in peninsular Florida. Through the kindness of Dr. Alan Stone, records have been received of specimens from Orla Vista, Orlando, Rock Springs, and Sanford, Florida. Of these, two specimens from Rock Springs, collected February 25, have "rather wide" bands, but the remainder are narrow-banded.

It would be reasonable to recognize the Floridian form as a distinct subspecies of *apicalis*. For the present, no name is applied, since the seasonal variation evident in other southeastern states suggests that the differences between Floridian and other populations may be the direct effect of the environment rather than indications of genetic differentiation. It is remotely possible that two species are involved but if so suitable differentiating characters have yet to be found. This question will probably remain unsettled until rearing experiments can be carried out.

The larvæ of *C. apicalis* also exhibit a wide range of variation in many characters. Certain of these variations appear to be correlated with the seasons, although not so well so as the variations of the adults. Those which are best correlated with the season are indicated in the following tabulation:

Summer form	*Winter form*
Smaller, pigmentation light.	Larger, pigmentation, especially of head, dark.
Air tube long, slender, about 2½ times as long as antenna, more expanded at tip than in winter form, both sides curving outward apically.	Air tube shorter and more robust, less than 2½ times as long as antenna, less expanded at tip, one side nearly straight.

All intergradations between these forms occur, sometimes even in one pool. The size and pigmentation is correlated in part at least with food supply. In a turbid pool larger, darker specimens are usually found, while in a clear pond with meager food supply small pale individuals occur. Thus climatic factors may produce the variation by their effect on larval food supplies rather than by a direct effect on the larvæ. Typical "summer" larvæ were found in certain situations in the middle of February, 1944, at Camp Shelby, near Hattiesburg, Mississippi, but most collections throughout March were of the "winter" type.

As with the adults, the typical summer individuals approach the characters of the Mexican *C. derivator,* which has an exceedingly long and slender air tube.

Unfortunately larval material, although more easily obtained in this species than adults, has been preserved in such small quantities that detailed information on the occurrence of the different types in different regions cannot be given. It is very clear, however, that in southern Mississippi the larger, darker larvæ with shorter, robust air tubes occur during approximately the months when broad-banded adults are to be found and that paler larvæ with long, slender tubes are collected during the remaining months. However, narrow-banded "summer" adults have been reared from dark, short-tubed "winter" larvæ.

CULEX (CULEX) NIGRIPALPUS THEOBALD

This primarily Neotropical species has been recorded from several of the southeastern states, but is common only in Florida. One hundred thirty-eight female specimens have been studied from the following localities in Florida: Apopka, Avon Park, Boca Raton, Leesburg, Mt. Dora, Palm Beach, Panama City, and Sebring. In this species males show the seasonal differences only inconspicuously, while no such differences were observed in larvæ.

In this species, as in *C. apicalis,* the specimens found during the cooler months of the year average larger, with more conspicuous abdominal bands, than those collected during the summer months. However, at no time during the year are all specimens of the large, banded type. Intermediate types are common. In size they resemble unbanded individuals but have a pale band on the fourth tergum and sometimes also on the third and fifth terga. It is such specimens that are listed as intermediate in Table 2.

The banded and unbanded types may be distinguished as follows:

Unbanded form	*Banded form*
Smaller.	Larger.
Abdomen appearing almost completely black from above, lateral patches of pale scales absent on first two or more segments and scarcely extending onto dorsum on following segments.	Lateral patches of pale scales present on all exposed abdominal segments, and extending across terga as narrow (one scale wide) white basal bands.

The seasonal distribution of these forms may be seen in Table 2.

TABLE 2

	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
Per cent unbanded	43	50	50	50	66	100	100	78	35
Per cent intermediate (slightly banded)	57	17	33	33	34	0	0	22	40
Per cent banded	0	33	17	17	0	0	0	0	25
No. of specimens studied	28	6	6	6	22	7	15	23	40

No specimens are available for December, January, and February.

It is clear that considerable percentages of banded and slightly banded specimens persist into the summer months of June and July. Whether they emerge during these months or are specimens which survive from the spring months is not known.

Specimens studied from more northern localities (Warner Robins, Georgia; Opelika, Alabama; Hattiesburg, Mississippi) are all of the unbanded type but all were collected in September or October.

Culex salinarius Coquillett is closely related to *C. nigripalpus*. The banded specimens of the latter resemble *salinarius* even more closely than the unbanded ones and do not run clearly to one species or the other in the key given by King, Bradley, and McNeel.[2] The pale abdominal scales of *C. salinarius* are yellowish

[2] King, W. V., C. H. Bradley, and T. E. McNeel. 1942. The mosquitoes of the southeastern states, U. S. Dept. Agr. Misc. Publ., 336, 96 p., 26 figs., 6 pls.

or golden, while those of *nigripalpus* are white. Furthermore, when the pale scales are numerous in *C. salinarius* they are most extensive at the apex of the abdomen, often largely covering the seventh segment, while in banded *nigripalpus* the pale scales are most numerous on the middle abdominal segments and do not cover the seventh segment. The two species are easily distinguishable by characters of the male genitalia and the larvæ.

CULEX (MELANOCONION) SPP.

Three species of *Melanoconion* are widespread in the southeastern states. Externally they are indistinguishable, or nearly so, in the females, although the larvæ and male genitalia are quite different. The cibarial armature of the female of one species is distinguishable from that of the others. These three species are *C. erraticus* Dyar and Knab, *C. peccator* Dyar and Knab, and *C. pilosus* (Dyar and Knab).

Winter specimens, chiefly females, of *C. erraticus* and probably of one or both of the other species have been noted with white basal bands two or three scale-rows in width on the abdominal segments. At other seasons of the year pale scales of the abdominal terga are confined to patches at the sides of the abdomen. Available material is insufficient to give further significant data on the occurrence of banded forms of *Melanoconion*.

The abdominal bands of some winter specimens of *Melanoconion* are definitely conspicuous, for which reason they cannot be properly run through such keys as that of King, Bradley and McNeel.[2]

An examination of series of *Culex pipiens* Linnæus, *C. quinquefasciatus* Say, *C. salinarius* Coquillett, and *C. restuans* Theobald showed much individual variation but none clearly correlated with the seasons.

SUMMARY

Seasonal variation occurs in larvæ and adults of *Culex* (*Neoculex*) *apicalis* and in adults of *C.* (*Culex*) *nigripalpus* and *C.* (*Melanoconion*) spp. in the southeastern United States. In all three cases the adults have more extensive white areas on the abdomen in winter than in summer, and in at least the first two species winter specimens average larger than summer ones.

Winter larvæ of *apicalis* are not only larger, but darker and structurally slightly different from summer specimens. Seasonal differences were not observed in four other species of *Culex*.

In *Culex apicalis* conspicuous seasonal variation in adults is apparently limited to the southeastern states other than Florida. In the north and west all specimens are similar to the winter form of the southeast, while in Florida the summer form of the other southeastern states appears to occur throughout the year.